skew-symmetric if and only if $\delta = -\gamma$, $\epsilon = \gamma$, and then $M_2M_3 = \gamma M_4$, $M_2M_4 = -\gamma M_3$, $M_3M_4 = \gamma M_2$. Writing i, j, k for M_2, M_3, γM_4, we have the multiplication table of quaternions. Or we may form the matrix M and write X_k for the sum of the products of the elements of its kth row by $\xi_1, \ldots, \xi_4$, and take $\gamma = 1$ (by multiplying x_4, ξ_4, X_4 by γ); we obtain (11′) for $c_2 = c_3 = -1$. Hence we have again obtained the quaternion algebra without assuming the associative law. The case $n = 8$ is being investigated in this way by one of my students.

[1] Frobenius, *Jour. für Math.*, **84**, 1878 (59).

[2] Dickson, *Linear Algebras*, "Cambridge Tracts in Mathematics and Mathematical Physics," No. **16**, 1914 (10–12).

[3] Dickson, *Bull. Amer. Math. Soc.*, **22**, 1915 (53–61).

[4] By (7), $e_2e_3 = e_3e_2 = 0$.

[5] Lagrange, *Nouv. Mém. Acad. Roy. Sc. de Berlin*, année 1770, Berlin, 1772 (123–133); *Oeuvres* de Lagrange, **3**, 1869 (189). Reproduced in Dickson's *History of the Theory of Numbers*, II, 1920 (279–281).

[6] Dickson, *Trans. Amer. Math. Soc.*, **13**, 1912 (65).

[7] Dickson, *Annals of Math.*, **20**, 1919 (155–171, 297).

[8] Dickson, *Comptes Rendus du Congrès Internat. Math.*, Strasbourg, 1920 (131–146).

NOVOCAINE AS A SUBSTITUTE FOR CURARE[1]

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Since the recent war, the need of a substitute for the Indian arrow poison, curare, has been keenly felt in many physiological laboratories. While investigating the activity of certain local anesthetics, it was found that novocaine, in its effect upon the neuro-muscular mechanism of frogs, duplicates in many particulars the unique action of curare.

If the sciatic nerve of a sciatic-gastrocnemius preparation is bathed in a strong solution of novocaine (2.5 per cent in water or in physiological salt solution) for as long as twenty minutes, no decrease in its conductivity can be observed. However, if the muscle itself is bathed in such a solution (by direct immersion or, "painting" with a camel's hair brush) the power of reacting to nervous stimulation is destroyed within three to five minutes, though ability to respond by contraction to direct electrical stimulation remains unimpaired. Thus, in the action of novocaine there is a complete duplication of the properties originally described by Claude Bernard for curare.

Whether novocaine acts directly upon the end-plates of the motor fibers or upon some membrane intermediate between the plates and the

[1] Contributions from the Zoölogical Laboratory of the Museum of Comparative Zoölogy at Harvard College. No. 330.

muscle has not been determined. A dye that I have made by linking novocaine with a benzene nucleus was found to be physiologically active, like the 2.5% novocaine, and appears to stain the elements acted upon by the novocaine. When the stain is diazotized directly into the living muscle, by putting the tissue first into novocaine and then into a solution of the staining base, only the muscle nuclei take the stain deeply, the nervous elements of the end-plates as well as the motor fibers remaining uncolored. It seems reasonably certain, therefore, that novocaine acts upon some constituent of the neuro-muscular mechanism beyond the end-plates. The significance of the affinity of the dye for the muscle nuclei is as yet unknown. The object of this note is to direct the attention of physiologists to a convenient substitute for curare.

NOTE ON A METHOD OF DETERMINING THE DISTRIBUTION OF PORE SIZES IN A POROUS MATERIAL

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The pressure required to force mercury into a capillary pore of radius, r, is $\frac{-2\gamma\cos\theta}{r}$, where γ is the surface tension and θ the angle of contact. Upon this relation can be based a method for determining the effective pore diameters in a porous material such as charcoal. If pores of various diameters are present, one may determine also the fraction of the total porosity which is due to pores having effective diameters lying between any two stated limits. The procedure would be as follows:

The coarsely granular sample of the thoroughly outgassed material is weighed and placed in a steel pressure bomb which is then evacuated until all adsorbed gases are removed. Pure mercury is then admitted to fill the bomb and a series of pressure and volume measurements are made at various pressures up to the highest pressure it is desired to employ.

The decrease in volume, ΔV, accompanying a small pressure increase of Δp, in any part of the range must evidently be due to the filling of pores whose effective radii lie between the limits r and $r - \Delta r$, or

$$\frac{\Delta r}{\Delta p} = \frac{-2\gamma\cos\theta}{p^2}.$$

A blank experiment without the porous material should of course be made in order to correct for the compressibility of the mercury and the expansion of the bomb under pressure. For accurate results the compressibility of the porous material, and the variation of γ and θ with p should also be known.